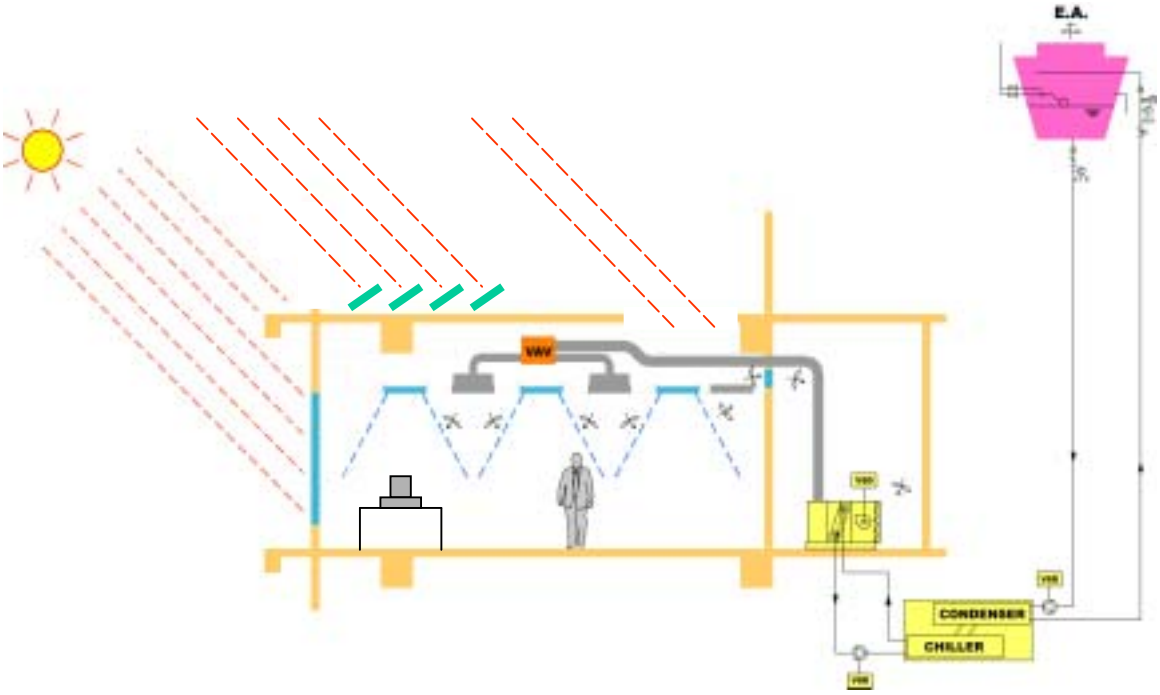
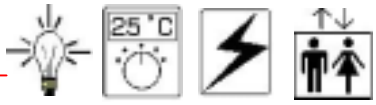
Performance-based

Building Energy Code

2005 EDITION





EMSD

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FOREWORD

Buildings alone consume a significant amount of energy in Hong Kong and energy conservation in buildings plays an important role in our economic development and environmental sustainability. To promote and ensure energy efficiency in buildings, the following building energy codes have been developed in Hong Kong:

- Code of Practice for Overall Thermal Transfer Value in Buildings 1995
- Code of Practice for Energy Efficiency of Lighting Installations (2005 Edition)
- Code of Practice for Energy Efficiency of Air Conditioning Installations (2005 Edition)
- Code of Practice for Energy Efficiency of Electrical Installations (2005 Edition)
- Code of Practice for Energy Efficiency of Lift and Escalator Installations (2005 Edition)

These codes address energy efficiency requirements by setting out minimum design requirements.

The code of practice for Overall Thermal Transfer Value (OTTV) was promulgated under Building (Energy Efficiency) Regulation (Cap. 123 Sub. Leg. M), which came into effect on 21 July 1995. The Regulation is the first set of legislation in Hong Kong to control energy-efficient design in buildings. It specifies the statutory control of the design of building envelopes of new commercial buildings and hotels by adopting the OTTV standard. Apart from the OTTV standard, four codes for building services design were developed by the Electrical & Mechanical Services Department (EMSD). They are implemented on a voluntary basis under EMSD's Hong Kong Energy Efficiency Registration Scheme for Buildings.

The existing codes are substantially prescriptive in nature, and the submission party is required to comply with all the requirements for each building component outlined in the codes. The prescriptive requirements are simple to use and provide a straight forward approach for the code users to determine whether the buildings concerned are code-compliant or not. The prescriptive approach sets forth fundamental requirement on the design of the building components (such as the effect of daylighting on artificial lights and air conditioning).

As an advance step, an alternative path to the prescriptive codes - the Performance-based Building Energy Code (PB-BEC) is developed. ***The PB-BEC and the existing prescriptive codes form a set of comprehensive building energy codes that addresses energy efficiency requirements of buildings in a systematic and holistic way.*** Designers are encouraged to adopt a proactive approach to work well above the minimum requirements of the codes, and the performance approach will provide a more flexible method for considering and evaluating innovative designs and new building techniques.

The purpose of the PB-BEC is to provide the minimum requirements for the energy-efficient design of buildings using a performance-based approach that focuses on the total building energy budget. A separate document, the "Guidelines on PB-BEC", is developed to provide a detailed elaboration of the requirements, calculation methodology and compliance procedures. The Guidelines also includes suggestions for good practices and examples of application. Users are strongly recommended to read this Code in conjunction with the Guidelines.

It should be noted that this Code is <u>not</u> to replace, but to provide an alternative means for complying with the existing prescriptive codes. EMSD welcomes suggestions for improving this Code. EMSD's codes could be downloaded at http://www.emsd.gov.hk/emsd/eng/pee/eersb.shtml. Enquiries could be sent to hkeersb@emsd.gov.hk.

The PB-BEC was developed by the Task Force under the ***Energy Efficiency & Conservation Sub-committee*** of the Energy Advisory Committee. The Task Force members include -

Organization	Representative
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Hong Kong Chapter	Ir Dr. Leonard Chow
The Hong Kong Institute of Architects	Mr. WONG Kam-sing
The Hong Kong Institution of Engineers	Ir Victor CHEUNG
The Hong Kong Institute of Surveyors	Mr. Nelson HO
City University of Hong Kong	Dr. Danny H.W. LI
Hong Kong University of Science and Technology	Dr. Christopher CHAC
The Hong Kong Polytechnic University	Dr. WANG Shengwei
The University of Hong Kong	Mr. Stephen LAU
Hong Kong Electrical Contractors' Association Ltd.	Mr. HO Pun Hing
Hong Kong E & M Contractors' Association Ltd.	Mr. James CHIU, JP
The Association of Consulting Engineers of Hong Kong	Ir WONG Wai-ho
The Hong Kong Federation of Electrical & Mechanical Contractors Ltd.	Mr. T.L. CHAU
The Real Estate Developers Association of Hong Kong	Mr. Cary CHAN
Architectural Services Department	Mr. WONG Hon-kwok
Buildings Department	Mr. J. R. DOBBING Mr. W.H. AU
Electrical & Mechanical Services Department	Dr. K.M. LEUNG Mr. Welman LEUNG Mr. David LI
Environment, Transport & Works Bureau	Mr. Bruno LUK
Housing Department	Mr. S.C. Leung Mr. T.K. NG
Parsons Brinckerhoff (Asia) Ltd. in association with Architecture Design & Research Group Ltd.	Mr. Vincent TSE Mr. Kenneth LI Dr. Sam HUI Prof. Bernard LIM Mr. Daniel CHEUNG

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LIST OF ABBREVIATIONS AND ACRONYMS

EMSD	Electrical and Mechanical Services Department
HVAC	Heating, ventilating and air-conditioning
kWh	kilowatt hour
l/s/psn	litre per second per person
MWh	megawatt hour
PB-BEC	Performance-Based Building Energy Code
OTTV	Overall thermal transfer value
RPE	Registered Professional Engineer
TRY	Test Reference Year
W/m^2	Watt per square metre
$W/m^2\,^oC$	Watt per square metre per degree Celcius

1. PURPOSE

1.1 Objective

1.1.1 The objectives of this Code are to facilitate efficient use of energy in buildings and to promote innovative approaches to achieve optimum building energy performance.

1.1.2 The Code provides the criteria and the minimum standards for energy efficiency in the design or retrofit of buildings and describes the methods for determining compliance. It also intends to encourage energy efficient designs and good practices that exceed these criteria and minimum standards.

1.2 Function

1.2.1 A building, including its architectural elements, fabric and services, shall be designed, constructed, operated, and maintained in a manner that achieves the efficient use of energy throughout its life, without compromising the building function, comfort, health, safety, or the productivity of the occupants and with appropriate regard to economic considerations.

1.2.2 The Code permits the use of renewable energy. It encourages cost-effective energy use of building components including building envelope, lighting, HVAC, electrical installations, lift and escalator, and other equipment.

1.2.3 The Code allows the use of innovative approaches and techniques to achieve effective utilisation of energy and optimum building performance. New or innovative design features in architecture and/or building engineering, which cannot be accounted for in the prescriptive codes, shall also be studied and evaluated using the approach specified in this Code.

1.3 Performance Requirements

1.3.1 A building shall have an adequate level of thermal and energy performance to ensure efficient use of energy. This Code requires building projects to meet or exceed a performance target, and allows flexibility in the building design.

1.3.2 The Code specifies the methodology for determining the building energy budget for a building. This building energy budget represents the upper limit of energy use allowed for a particular building.

1.3.3 The building owner or designer is permitted to trade off different aspects of the building design, one against the other, as long as the total design energy does not exceed the allowed energy budget.

1.3.4 When establishing the basic requirements and control framework in this Code, references were made to the existing building energy codes in Hong Kong and overseas experience. The basic requirements are a prerequisite to this Code and must be met by all proposed designs.

2. SCOPE

2.1 Types of Buildings

2.1.1 This Code applies to the design of new buildings classified as commercial buildings and hotels under the Building Regulations.

2.1.2 Where different parts of a building are used for different purposes, this Code applies only to those parts which are used for commercial or hotel purposes, or any purpose ancillary to such use. Any reference to "building" in this Code shall be construed as a reference to those parts.

2.1.3 When a building is designed and constructed for more than one type of occupancy, the space for each occupancy shall meet the provisions of this Code applicable to that occupancy.

2.2 Exemptions

2.2.1 This Code does not apply to any area or any part of the building which is constructed, used or intended to be used for domestic, medical or industrial purposes.

2.2.2 Where specifically noted in this Code, certain buildings or elements of buildings shall be exempted.

3. DEFINITIONS

The expressions that appear in this Code are defined below. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used.

"Authority": is a body that has legal powers and rights for implementing this Code. This shall mean Electrical & Mechanical Services Department, unless otherwise stipulated in the legislation.

"Air Conditioning Code": means the Code of Practice for Energy Efficiency of Air Conditioning Installations (1998 Edition) and the subsequent amendment.

"Building envelope": is the ensemble of the building's external walls as defined under Building Regulations.

"Commercial building": as defined under Building Regulations.

"Conditioned floor area": is the floor area of conditioned space , as measured at the floor level within the interior surfaces of walls enclosing the conditioned space.

"Conditioned space": is space in a building that is either directly conditioned or indirectly conditioned.

"Design documents": means the documents for describing the building design or building system design, such as drawings and specifications.

"Design energy consumption": is the energy consumption of a proposed building design, or portion of a building, calculated for the designed building with the approved procedures specified in this Code.

"Designed building": means the building, group of buildings or portions of the building for which compliance with this Code is being sought. The proposed design includes the building envelope, HVAC, lighting and electrical systems, and other energy consuming equipment.

"Energy budget": is the maximum amount of source energy that a proposed building, or portion of a building, can be designed to consume, calculated for the reference building with the approved procedures specified in this Code.

"Electrical Code": means the Code of Practice for Energy Efficiency of Electrical Installations (1998

Edition) and the subsequent amendment.

"Floor area": means the aggregate internal floor area (excluding external wall / glazing thickness) of a building or a building space.

"Guidelines": means the Guidelines on PB-BEC.

"Gross floor area": as defined under Building Regulations.

"Hotel": as defined under Building Regulations.

"HVAC system": means the equipment, distribution systems, and terminals that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning (HVAC) to a building or portion of a building.

"Lift/Escalator Code": means the Code of Practice for Energy Efficiency of Lift and Escalator Installations (2000 Edition) and the subsequent amendment.

"Lighting power": means the electrical power consumed by lighting installations of an illuminated space.

"Lighting Code": means the Code of Practice for Energy Efficiency of Lighting Installations (1998 Edition) and the subsequent amendment.

"Modelling assumptions": are the conditions (such as weather conditions, thermostat settings and schedules, internal heat gain, operation schedules, etc.) that are used for calculating a building's annual energy consumption in this Code.

"New building": as defined under Building Regulations.

"Non-renewable energy": means energy derived from non-renewable energy sources such as coal, oil and natural gas.

"OTTV Code": means Code of Practice for Overall Thermal Transfer Value in Buildings 1995 and the subsequent amendment.

"Overall thermal transfer value" (OTTV) (unit: W/m^2): means the overall thermal transfer value defined and specified in the OTTV Code.

"Performance compliance report": means a record of the clearly presented information that is input, processed and output by numerical analysis, intended to accompany an application for compliance with this Code.

"Prescriptive codes": means the existing building energy codes for OTTV, lighting, air conditioning, electrical, and lift & escalator installations.

"Reference building": means a generic building design of the same size and shape as the designed building that complies with the prescriptive requirements and has prescribed assumptions used to generate the energy budget.

"Reasonable": means based on or using good judgement and therefore fair and practical.

"Recovered energy": means waste energy recovered at the building site that is used to offset consumption of purchased fuel or electrical energy supplies.

"Renewable energy": means thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation or other renewable energy sources at the building site and used to offset consumption of purchased fuel or electrical energy supplies. For the purposes of applying this Code, renewable energy shall not include passive heat gain through fenestration systems.

"Space conditioning system": is a system that provides either collectively or individually cooling, heating, or ventilating within or associated with conditioned spaces in a building.

"Shading coefficient (SC)": is the ratio of solar heat gain at normal incidence through glazing to that through 3 mm thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices.

"Skylight-roof ratio": is the ratio of skylight area to gross roof area.

"Thermal block": means a collection of one or more HVAC zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

"Throttling range" (Dead band): means the range of values within which an input variable can be varied without initiating any noticeable change in the output variable.

"Type categories" refers to the requirements of building type categories in Table A2 of Appendix III, or space type categories in Table A3 of Appendix III.

"Unconditioned space": is the enclosed space within a building that is not directly conditioned.

"Window-wall ratio": is the ratio of vertical fenestration area to gross exterior wall area.

4. GENERAL APPROACH

4.1 Control Framework

4.1.1 This Code forms a part of a set of comprehensive building energy codes to control energy-efficient design in buildings. Figure 1 shows the framework of the comprehensive building energy codes and the relationship between its major components. There are two levels of control:

(a) *Basic Requirements* are those that must be met for the building and no trade-off is permitted; and

(b) *Prescriptive/Performance Requirements* are additional criteria for determining compliance with the set of codes.

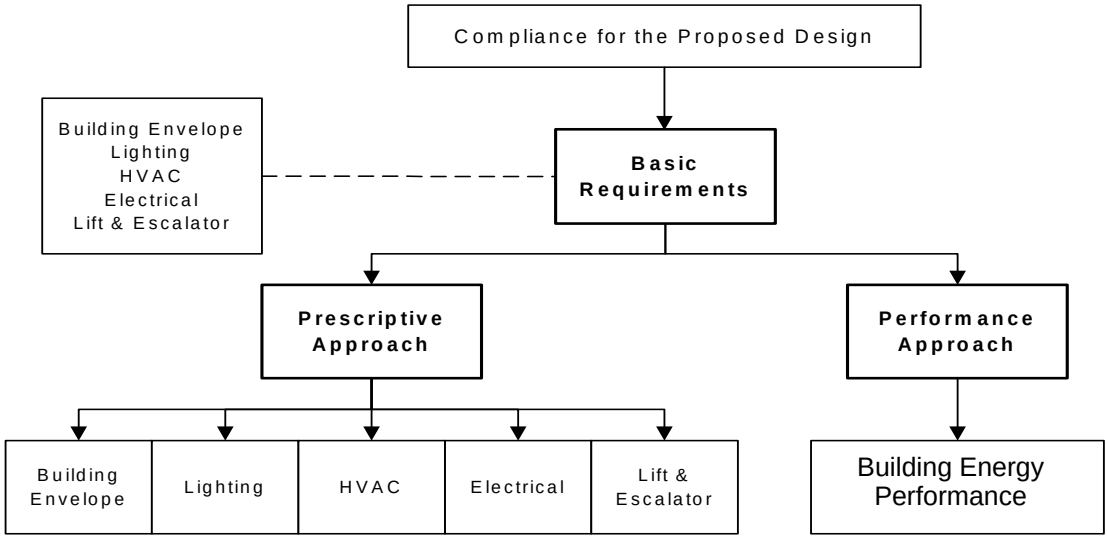

Figure 1. Framework of the comprehensive building energy codes

4.1.2 The prescriptive codes (OTTV, lighting, air conditioning, electrical, and lift & escalator installations) do not distinguish the two levels of control requirements (the two levels are integrated as one). In order to define clearly the intended control criteria for this Code, a list of basic requirements is provided (see Appendix I).

4.1.3 Under the comprehensive framework, the use of the prescriptive codes as an acceptable design solution is allowed. The prescriptive codes will remain intact for design in which a minimum code-compliance effort is of prime concern and no trade-off is required.

4.2 Basic Requirements

4.2.1 As a prerequisite to this Code, the building or portions of the building for which compliance with this Code is being sought shall meet the basic requirements specified in Appendix I.

4.2.2 The basic requirements are fundamental issues justified largely on the consensus for promoting good energy efficient practices in building design and operation. They are usually related to the measures that cannot be accurately modelled (such as insulation, power quality, lift power) or that are inherently energy effective (such as high luminous efficacy, energy efficient motor). No trade-off shall be made for them.

4.2.3 If a system or component has not been completely determined and specified, its information shall be compiled based on "reasonable" assumptions of the design or construction of such system or component in the future. These assumptions shall be based on appropriate professional judgement and all of them shall be documented so that future systems and component can be checked to ensure compliance with the Code.

4.3 Prescriptive and Performance Options

4.3.1 *Prescriptive Approach*. A proposed design will comply with the prescriptive requirements if it meets all the building component requirements outlined in the prescriptive codes (deem-to-satisfy). This is the simplest compliance path and requires no energy calculation. Under the prescriptive approach, the "basic" and "prescriptive" requirements for each code are not distinguished from each other, and they have been integrated in the code documents.

4.3.2 *Performance Approach*. Performance compliance is an option that permits a proposed design to deviate from prescriptive requirements provided that the proposed design can be shown

to have annual energy consumption no greater than that of a reference case that satisfies the prescriptive requirements. Numerical analysis shall be carried out for this purpose and it shall comply with the specification in this Code.

4.3.3 The performance path provides an opportunity for the building designer to evaluate and take credit for innovative energy efficient designs, materials, and equipment (such as daylighting, heat recovery and renewable energy) that cannot be accounted for in the prescriptive path. To demonstrate code compliance through a performance approach, the designer shall conduct the technical analysis and evaluation. The onus will be on the designer to present a design solution together with appropriate predictive evidence of its energy behaviour.

5. COMPLIANCE METHOD

This Section gives the compliance method of the performance approach.

5.1 Total Energy Budget Approach

5.1.1 Compliance with this Code requires the calculation of a *design energy consumption* through a detailed energy analysis of the proposed building design. The design energy consumption is compared against a *total energy budget* which is determined through calculation of the annual energy consumption of a reference building design configured to meet the requirements of the prescriptive codes. Figure 2 shows the concept of the compliance method.

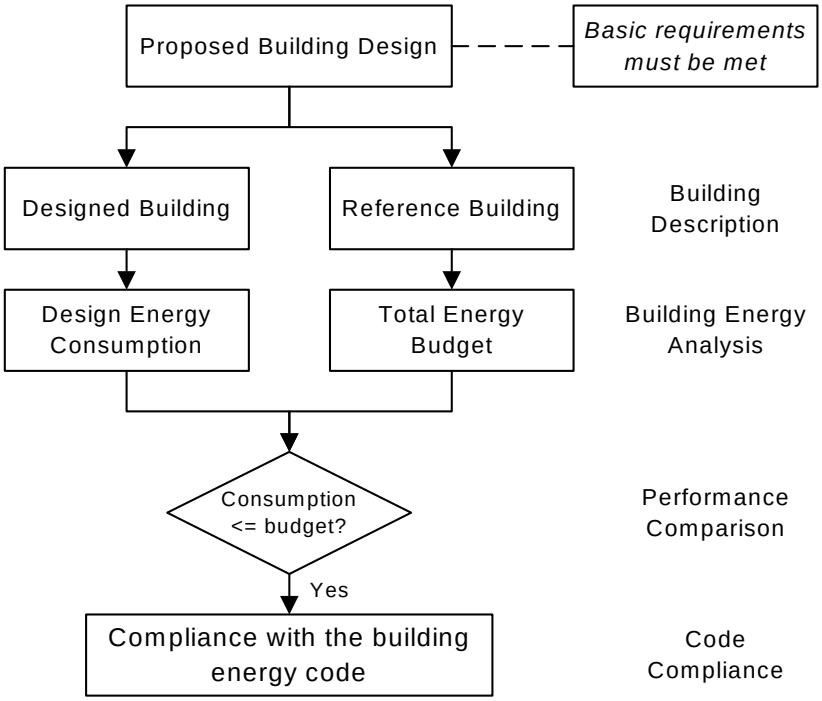

Figure 2. Compliance method for the performance approach

5.1.2 Compliance with this Code will be achieved if all the basic requirements in Appendix I are met and the design energy consumption does not exceed the total energy budget when calculated in accordance with the specified procedures. It allows certain systems to exceed the minimum requirements on the condition that the energy performance for the other systems in the building is improved to compensate for the non-compliance of the specific systems (i.e. trade off among the systems).

5.1.3 Information of the proposed building design shall be translated into building

description data required for the energy calculation or simulation. The *designed building* shall be represented in the energy calculation tool using the format required for the building energy analysis and simulation process.

5.1.4 A ***reference building*** shall be developed by modifying the description of the designed building. The reference building shall have all the features of the designed building, but be modified to meet the exact requirements of the prescriptive codes. This will allow broadly the comparison of the energy performance of the proposed building design with a custom energy budget based on the prescriptive requirements.

5.1.5 *Compliance Calculations*. Building designers need to choose appropriate calculation methods, including the selection and use of suitable numerical analysis. The design energy consumption and total energy budget shall be calculated using the same energy analysis method and with consistent methodology.

5.2 Numerical Method for Building Energy Analysis

5.2.1 The numerical method for the building energy analysis shall be designed for the estimation of energy consumption in buildings in a comprehensive manner and shall include calculation methodologies for the building components or systems being considered.

5.2.2 The use of an hour-by-hour, full-year, multiple-zone numerical analysis for modelling and simulating the building energy performance is required. Simpler tools are allowed if they have been shown to produce equivalent results for the type of building and relevant building features and/or systems being considered.

5.2.3 The simulation program shall use scientifically justifiable techniques and procedures for modelling building loads, systems, and equipment. It shall simulate or model the thermal behaviour of buildings and the interaction of their building fabric, HVAC, lighting and other relevant energy consuming equipment. A list of commonly used computer programs capable of handling such complex calculations is given in Appendix II.

5.2.4 The simulation program to be used shall have the ability to either directly determine the design energy consumption and total energy budget, or produce simulation reports of energy use suitable for determining the design energy consumption and total energy budget using a separate calculation engine.

5.2.5 The simulation program shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates for both the designed building and reference building.

5.2.6 When a simulation program is used to verify compliance with this Code, essential information about its modelling capabilities, calculation techniques and validation results shall be provided for evaluation and approval by the Authority.

5.3 Limitations and Nature of Numerical Approach

5.3.1 The total energy budget and the design energy consumption calculations are applicable only for determining compliance with this Code. They are not intended to be used to predict, document, or verify the actual energy consumption of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this Code, and precision of the calculation tool.

5.3.2 The total energy budget is a numerical target for annual energy consumption. The

numerical approach is intended to assure neutrality with respect to choices of architectural design, HVAC system type, etc., by providing a budget target that is independent of any of these choices wherever possible (i.e. for the reference building). The budget target shall be determined from consistent specification and calculation method so that the numerical procedure is repeatable.

5.3.3 The specification of the reference building is necessary to assure repeatability of the calculation procedure and ensure consistent results. The specification and related parameters may or may not have practical significance. Some of the parameters are modelling assumptions that allow a calculation of the energy consumption resulting from compliance with the prescriptive requirements. Some are established based on professional experience and judgement on typical design practices. They must not be treated as the best or recommended energy efficiency practice.

5.3.4 The purpose of the energy calculation is to develop fair and consistent evaluations of the energy performance of the effects of deviations from the prescriptive requirements. Many simplifying assumptions are needed to rationalise the simulation/modelling exercise without compromising the intent. Appendix III explains the modelling assumptions and methods in details.

6. EVALUATION OF BUILDING ENERGY PERFORMANCE

6.1 General Requirements

6.1.1 *Trade-Offs Limited to Compliance Areas*. When compliance applies to a portion of a building, only the calculation parameters related to the systems for the areas concerned shall be allowed to vary. Parameters in relation to unmodified existing conditions or to future building components shall be identical for both the total energy budget and the design energy consumption calculations.

6.1.2 *Climatic Data*. Weather data used with the simulation program must be appropriate for the site and for the complexity of design features. The climatic data used in the energy analysis shall cover a full calendar year (usually 8,760 hours) and shall reflect coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location (for example, the data from the Hong Kong Observatory). The weather data shall be fully verified and justified. The same weather data must be used for the calculation of the designed building and reference building. The year 1989 has been selected as the "Test Reference Year" (TRY) for Hong Kong. Weather data and calendar for 1989 shall preferably be used in the energy calculation.

6.1.3 *Operating Schedule*. Building operation shall be simulated for a full calendar year. Operating schedules shall include hourly profiles for daily operation and shall account for variation between weekdays, weekends, holidays, and any seasonal operation, where applicable. Schedules shall model the time-dependent variations of occupancy, lighting, equipment loads, thermostat settings, mechanical ventilation, HVAC equipment availability, and any process loads.

6.1.4 *Occupant-sensitive Features*. Occupant behaviour should not be relied upon to achieve consistent and permanent reductions in building energy consumption for compliance with this Code. Design features that depend on the co-operation of the occupants (such as the use of blinds) shall be excluded from the energy calculation.

6.1.5 *Renewable Energy*. Useful energy generated from renewable energy sources or recovered from suitable sources can be considered in the evaluation of building energy performance, provided that the sources are reliable and appropriate method is used to estimate the energy generation. To provide credit for these sources in the code compliance, renewable energy or recovered energy for routine duty can be excluded from the design energy consumption allowed for the building. Where renewable energy or recovered energy are used, the reference building design shall be based on the energy source used as the back-up energy source or

electricity if no backup energy source has been specified.

6.1.6 *Professional Judgement*. Although certain modelling techniques and compliance assumptions applied to the designed building are fixed or restricted, there are other aspects of computer modelling for which professional judgement is necessary. In those instances, it must be exercised properly in evaluating whether a given assumption is appropriate. The Authority has full discretion to accept or not a particular input, especially if the user has not substantiated the value with supporting evidence and documentation.

6.1.7 *Exclusion of Essential Safety and Health Installations*. The energy calculation shall normally exclude such consumptions/loadings as for fire services, essential, health and safety-related installations.

6.2 Determination of Energy Consumption for the Designed Building

6.2.1 *Simulation Model*. The simulation model of the designed building shall be consistent with the design documents, including proper accounting of window and wall types and area; lighting power and controls; HVAC system types, sizes, and controls; and so on. The major building systems including building envelope, lighting and HVAC must be included in the energy calculation. Other building systems are often excluded or kept constant in the building energy simulation. But on an exceptional situation (see Section 6.4), these systems may be included in the energy analysis, provided that an appropriate calculation method is proposed and demonstrated to the satisfaction of the Authority.

6.2.2 *System Capacities and Data*. When HVAC, lighting and other appropriate building systems and equipment are included in the energy calculation, they shall be simulated for the designed building using capacities, rated efficiencies, and part-load performance data for the proposed equipment as provided by the equipment manufacturer. If a system or equipment has not been completely determined and specified, its information shall be based on "reasonable" assumptions of the design or construction of such system or equipment. These assumptions shall be based on appropriate professional judgement and all of them shall be documented so that these systems and equipment can be checked to ensure compliance with the Code at a later stage of the design.

6.2.3 *Yet-to-be-designed Features*. When the method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the designed building so that they minimally comply with applicable requirements of the prescriptive codes. Where the space classification for a portion of the building is not known, the portion shall be assumed a reasonable occupancy appropriate to the building project. All the assumptions shall be documented and is subject to verification.

6.2.4 *Building Envelope*. All components of the building envelope in the designed building shall be modelled as shown on architectural drawings or as installed for existing building envelopes. If necessary, reference should also be made to the approved plans in the relevant submission for the OTTV Code.

6.2.5 *Lighting*. Lighting power in the proposed design shall be determined as follows:

(a) Where a complete lighting system exists, the actual lighting power shall be used in the model.

(b) Where a lighting system has been designed, lighting power shall be determined in accordance with the design.

(c) Where no lighting system has been specified but it is expected, lighting power shall be determined in accordance with building and space type categories in Appendix III.

6.2.6 *HVAC*. The HVAC system type and all related performance parameters in the proposed design shall be determined as follows:

(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.

(b) Where an HVAC system has been designed, the HVAC model shall be consistent with the design. Some simulation software might require the efficiencies of mechanical equipment to be adjusted from actual design conditions to the standard rating conditions.

(c) Where no cooling system has been specified but it is expected, the cooling system shall be modelled as a simple air-cooled single-zone system, one unit per thermal block. The system characteristics shall be identical to the system modelled in the reference building.

(d) Where no heating system has been specified but it is expected, the heating system shall be modelled as electric. The system characteristics shall be identical to the system modelled in the reference building.

6.2.7 *Lift and Escalator*. Good energy efficient practices of lift and escalator design are specified in the basic requirements and normally no trade-off shall be allowed. Under an exceptional situation (see Section 6.4), lift and escalator systems may be included in the energy analysis, provided that an appropriate calculation method is proposed and verified.

6.2.8 *Other Systems*. Other building systems may be modelled using exceptional calculation methods (see Section 6.4). If they are modelled, performance shall be as indicated on design documents. Miscellaneous internal loads, such as those due to office and other equipment, shall be estimated based on the building and space type categories in Appendix III.

6.2.9 *Exclusion of Building Components and Systems*. To simplify the calculation procedures, some building components and systems in the proposed design may be excluded from the simulation model provided that:

(a) the component energy usage does not affect the energy usage of systems and components that are considered for trade-off; or

(b) the excluded components can meet the relevant requirements of the prescriptive codes.

6.2.10 *Alterations and Additions*. For a design relating to alterations or additions of an existing building, on the building itself or its building services, it is acceptable to demonstrate compliance using building models that exclude parts of the existing building provided all of the following conditions are met:

(a) Work to be performed in the excluded parts of the building shall meet the requirements of the prescriptive building energy codes.

(b) The excluded parts of the building are served by HVAC systems that are entirely separate from those which are included in the building model.

(c) Design space temperature and HVAC system operating set points and schedules, on either side of the boundary between included and excluded parts of the building, are identical.

6.2.11 *Limitations to the Simulation Program*. If the simulation program cannot model a component or system included in the designed building, one of the following methods shall be used subject to the approval of the Authority:

(a) Ignore the component or system if the impact on the trade-offs being considered is not significant.

(b) Model the component or system by substituting a thermodynamically similar component or system model.

(c) Model the component or system using the same component or system of the reference building.

Whichever method is selected, the component shall be modelled identically for both the designed

building and reference building.

6.3 Determination of Energy Budget for the Reference Building

6.3.1 *Simulation Model*. The simulation model of the reference building shall be developed by modifying the model of the designed building as described in Section 6.2. Except as specifically instructed in 6.2 and in this section, all appropriate building systems and equipment shall be modelled identically for both the reference building and designed building.

6.3.2 *Building Envelope*. The reference building shall have identical conditioned floor area and identical exterior dimensions and orientations as the designed building, except as noted in (a), (b), and (c) in this clause. For existing building envelopes, the reference building shall reflect existing conditions prior to any revisions. For new building envelopes, the envelope model of the reference building shall be modified from that used in the designed building as follows:

(a) Opaque assemblies such as roof, floors, doors, and walls shall be modelled as having the same heat capacity as the designed building (non-trade-off).

(b) All roof surfaces shall be modelled with a solar absorptivity of 0.7 (non-trade-off).

(c) No shading projections are to be modelled; fenestration shall be assumed to be flush with the exterior wall or roof.

6.3.3 *OTTV*. The building envelope (including all external walls and roofs) of the reference building shall satisfy the requirements in the OTTV Code. To determine the appropriate envelope parameters for the reference building, the designer shall adjust from the envelope model of the designed building the combinations of the window-wall ratio and skylight-roof ratio, and the shading coefficients of windows and skylights so as to meet the OTTV requirements.

6.3.4 *Lighting*. Regarding lighting power density of the reference building, reference shall be made to the category determined for the designed building, that is building type or space type. Then, identify a corresponding type of space in the Lighting Code. Use the maximum allowable value for the type of space in the Lighting Code as the lighting power of the reference building. Lighting controls shall be the minimum required in the Lighting Code.

6.3.5 *HVAC*. The HVAC system and equipment type of the reference building shall be the same as the designed building, but the system and equipment of the reference building shall exactly meet the relevant requirements in the Air Conditioning Code.

6.3.6 *Lift and Escalator*. Lift and escalator systems are usually excluded in the building energy simulation. If they are considered in the energy analysis, the related systems or components shall be the same as those of the designed building.

6.3.7 *Other Systems*. Other systems and miscellaneous loads, if they are considered, shall be modelled as identical to those in the designed building. Where there are specific efficiency requirements in the prescriptive codes, these systems or components shall be modelled as having the lowest efficiency allowed by those requirements.

6.4 Exceptional Calculation Methods

6.4.1 Where no simulation program is available to adequately models a design, material, or device, the Authority may approve an exceptional calculation method to be used to demonstrate compliance with this Code. An application for approval of an exceptional method shall be made. The criteria for acceptance of exceptional calculation methods are not easy to define and the Authority will consider the specific case based on professional judgement and will provide a reasonable assessment.

6.4.2 For approval of an exceptional method, theoretical and empirical information verifying

the method's accuracy shall be submitted, which shall include the following documentations to demonstrate that the exceptional calculation method and results:

(a) make no change in any input parameter values specified by this Code and the Authority;

(b) provide input and output documentation that facilitates the Authority's review and meets the formatting and content required by the Authority; and

(c) are supported by clear and concise instructions for using the method to demonstrate that the energy budget requirement is met;

(d) are reliable and accurate relative to the appropriate computer program; and

(e) establishes factors that, when applied to the method's outputs, result in energy budgets that are equivalent to those in this Code.

6.4.3 When an exceptional method is proposed and used, a detailed evaluation report of the energy consumption of the designed building and the building's materials, components, and manufactured devices proposed to be installed to meet the requirements of this Code shall be provided. The evaluation shall include a copy of the technique, instructions for its use, a list of all input data, and all other information required to replicate the results.

7. SUBMISSION FOR COMPLIANCE

7.1 Documentation

7.1.1 Documents used to determine compliance with the Code shall include, but are not limited to: plans and specifications showing details of all pertinent data, features, equipment, and systems of a building including complete descriptions of materials, engineering data, test data, manufacturer's data, and all other data necessary to allow proper identification of components that affect a building's energy use.

7.1.2 An energy analysis report clearly presenting the energy performance of the designed building and reference building shall be submitted to the Authority to demonstrate the compliance. Standard forms for submission (see Appendix IV) shall be used wherever applicable and all information necessary for describing the simulation software, modelling assumptions, and simulation results shall be provided.

7.1.3 To clearly explain the simulation results, the following information shall be submitted:

(a) The total energy budget for the reference building and the design energy consumption for the designed building.

(b) A list of the energy-related features that is included in the design and on which compliance with the provisions of the code is based. This list shall document all energy features that differ between the models used in the total energy budget and the design energy consumption calculations.

(c) The input and output report(s) from the energy analysis simulation program containing the complete input and output files, as applicable. The information shall include a breakdown of energy usage by at least the following components: lights, internal equipment loads, space cooling and heat rejection equipment, space heating equipment, fans, pumps and other HVAC equipment. The output reports shall also show the monthly energy consumption profiles and the amount of time any loads are not met by the HVAC system for both the designed building and reference building.

(d) An explanation of any error or warning messages noted in the simulation program output.

7.2 Certification

7.2.1 Compliance using the procedures in this Code requires certification by a Registered Professional Engineer in Building Services, Mechanical or Electrical Disciplines. The energy analysis

and supporting documentation shall be prepared by a Registered Professional Engineer of the appropriate discipline.

7.2.2 The Registered Professional Engineer shall submit a formal certifying statement informing the scope of compliance and confirming the compliance with this Code. The statement shall be accompanied by a set of documents, including as-fitted/installation drawings, design calculations and standard forms as required in this Code.

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APPENDICES

Appendix I – List of Basic Requirements

1. Building Envelope

Building (Energy Efficiency) Regulation Cap. 123 Sub. Leg. M
The shading coefficient of window glass shall be not less than 0.25.

2. Lighting

Scope [Lighting Code 1.3]
Definitions [Lighting Code 2]
Minimum allowable luminous efficacy [Lighting Code 4.1]
Maximum allowable lamp control gear loss [Lighting Code 4.2]
Interior lighting control [Lighting Code 4.4]

3. HVAC

Definitions [Air Conditioning Code 2]

Air Side System
- System load design [Air Conditioning Code 4]
- Separate distribution system [Air Conditioning Code 5.1.1]
- Air leakage limit on ductwork [Air Conditioning Code 5.1.2]

Water Side System
- Pumping system – variable flow [Air Conditioning Code 6.1]
- Friction loss [Air Conditioning Code 6.2]

Control
- Temperature control [Air Conditioning Code 7.1]
- Humidity control [Air Conditioning Code 7.2]
- Zone control [Air Conditioning Code 7.3]
- Off hours control [Air Conditioning Code 7.4]

Insulation [Air Conditioning Code 8]

4. Electrical

Scope [Electrical Code 1]
Definitions [Electrical Code 2]

Power Distribution in Buildings
- High voltage distribution [Electrical Code 4.1]
- Minimum transformer efficiency [Electrical Code 4.2]
- Locations of distribution transformers and main LV switchboards [Electrical Code 4.3]
- Main circuits [Electrical Code 4.4]
- Feeder circuits [Electrical Code 4.5]
- Sub-main circuits [Electrical Code 4.6]
- Final circuits [Electrical Code 4.7]

Efficient Utilisation of Power
- Lamps and luminaries [Electrical Code 5.1]
- Air conditioning installations [Electrical Code 5.2]
- Vertical transportation [Electrical Code 5.3]
- Motors and drives [Electrical Code 5.4]
- Power factor improvement [Electrical Code 5.5]

Power Quality
- Maximum total harmonic distortion [Electrical Code 6.1]
- Balancing of single-phase loads [Electrical Code 6.2]

Metering and Monitoring Facilities
- Main circuits [Electrical Code 7.1]
- Sub-main and feeder circuits [Electrical Code 7.2]

5. Lift & Escalator

Scope [Lift/Escalator Code 1]
Definitions [Lift/Escalator Code 2]

Lifts
- Maximum allowable electrical power [Lift/Escalator Code 4.1]
- Energy management of lift cars [Lift/Escalator Code 4.2]
- Total harmonic distortion of motor drive systems [Lift/Escalator Code 4.3]
- Total power factor of motor drive systems [Lift/Escalator Code 4.4]

Escalators & Passenger Conveyors
- Energy management of escalators & passenger conveyors [Lift/Escalator Code 5.1]
- Maximum allowable electrical power of escalators & passenger conveyors [Lift/Escalator Code 5.2]
- Total harmonic distortion of motor drive systems [Lift/Escalator Code 5.3]
- Total power factor of motor drive systems [Lift/Escalator Code 5.4]

Appendix II – Commonly Used Programs for Building Energy Analysis

Some examples of commonly used programs (available for sale or free) for building energy analysis are shown in Table A1. This list is not meant to be exhaustive and the acceptance of a program for the compliance process shall be subject to approval of the Authority.

Table A1. Commonly used building energy simulation programs

	Information Sources
Detailed programs:	
BLAST (Version 3.0) (Building Load Analysis and System Thermodynamics program)	http://www.bso.uiuc.edu/BLAST/
DOE-2 (Version 2.1E) (Building energy simulation program supported by U.S. Department of Energy). Examples of PC version/interface of DOE-2 include: • ADM-DOE-2.1E • FTI-DOE2 • VisualDOE	http://gundog.lbl.gov/dirsoft/d2whatis.html http://www.eley.com
DOE-2.2 and PowerDOE (Other DOE-2 derivates)	http://doe2.com/ (also a freeware tool "eQUEST")
EnergyPlus (Version 1.0.1) (Program supporte by U.S. Department of Energy)	http://www.energyplus.gov/
ESP-r (Environmental System Performance (research) program)	http://www.esru.strath.ac.uk/Programs/ESP-r.htm
TRNSYS (Transient Systems Simulation program)	http://sel.me.wisc.edu/TRNSYS/ http://www.trnsys.com/
Proprietary programs:	
Carrier HAP (Hourly Analysis Program) (Current version 4.10)	http://www.carrier-commercial.com/software/
TRACE 600/700 (Trane Air Conditioning Economics)	http://www.trane.com/commercial/software/
Simplified programs:	
Energy-10 (Current version 1.6)	http://www.sbicouncil.org/enTen/
ENER-WIN (Current version 2002)	http://www.cox-internet.com/larryd/enerwin/

The building energy simulation program to be used in the modelling evaluation must be able to accurately estimate the energy use of the systems and components concerned. If the energy modelling of each of the systems and components identified cannot be assessed using one program, more than one program can be proposed and used for the calculation and analysis. Where multiple programs are proposed for use, the minimum requirement is that the most significant program shall model the building, lighting, air conditioning and ventilation systems with other programs proposed for the evaluation of other energy use such as daylighting benefits and power systems. The outcomes from each of the modelling programs shall provide an integrated result.

All compliance software, all algorithms used in the energy analysis engine shall be supported by peer-reviewed, referenceable, and published documentation. Documentation of the compliance

process shall be sufficient to ensure that all calculations are reproducible and verifiable. Limitations of the compliance software shall also be documented.

Appendix III – Modelling Assumptions and Methods

The detailed information described here are the modelling assumptions and methods for calculating the design energy consumption of the designed building and the total energy budget for the reference building. In order to maintain consistency between the two sets of calculations, the input assumptions in this Appendix shall be used.

"Prescribed" assumptions shall be used without variation. "Default" assumptions shall be used unless the designer can demonstrate that a different assumption better characterizes the building's use over its expected life. Any modification of a default assumption shall be used in modelling both the reference building and the proposed design unless the designer demonstrates a clear cause to do otherwise.

1. Orientations and Shape

1.1 *General Building Design* (prescribed assumption). The reference building shall consist of the same number of stories and gross floor area for each story as the designed building. Each floor shall be oriented exactly as the designed building. The geometric form shall be the same as the designed building. The orientation shall be the same as the designed building.

2. Space Use and Schedules

2.1 *Type Categories*. All "air-conditioned" thermal blocks could be classified as either building type (all spaces having the same function) or space type (spaces having different functions). Building type categories and their associated default operating schedules shall be selected from Table A2. Space type categories and their associated default operating schedules shall be selected from Table A3.

2.2 *Operating Schedules*. The schedule types listed in Tables A4 to A10 shall be input. The schedules shall be typical of the proposed building type as determined by the designer and approved by the Authority. Required schedules shall be identical for the designed building and reference building. Operating schedules other than the default values are allowed but should be clearly defined and justified.

3. Internal Loads

3.1 *Occupancy*. Occupancy schedules shall be default assumptions. The same assumptions shall be made in computing design energy consumption as are used in calculating the total energy budget. Occupancy levels vary by building type and time of day. Tables A2 and A3 summarise the density presented that will be used by each building and space type. Tables A4 to A10 establishes the percentage of the people that are in the building by hours of the day for each building type.

3.2 *Lighting*. Interior lighting power density for calculating the total energy budget shall be similar to the methodology in the Lighting Code. The lighting power used to calculate the design energy consumption shall be the actual adjusted power of the proposed lighting design. If the lighting controls in the proposed design are more energy efficient than those required by the Lighting Code, the actual installed lighting power shall be used along with the schedules reflecting the action of the controls to calculate the design energy consumption. Lighting levels in buildings vary based on the type of uses within buildings, by area and by time of day. Tables A4 to A10 contains the lighting energy profiles which establish the percentage of the lighting load that is ON in each reference building by hour of the day. Where there are specific requirements in the Lighting Code, the component efficiency in the reference building shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

3.3 *Equipment*. Equipment loads and profiles are default assumptions. The same assumptions shall be made in calculating design energy consumption as were used in calculating the total energy budget. Equipment loads include all general service loads that are typical in a building. These loads should include additional process electrical usage, but exclude HVAC primary or

auxiliary electrical usage. Tables A2 and A3 establishes the density in W/m^2 to be used. The equipment energy profiles shall be determined from Tables A4 to A10.

Table A2. Building type categories: default assumptions

						Service Water Heating (W-person)
Office	13	8	A	20	10	As design
Restaurant	5	10	B	40	20 W/psn(*)	As design
Retail	10	8	C	30	---	As design
Mall/Concourse/Atria	10	1 l/s/m^2	C	30	---	As design
Hotel	25	30 l/s per room	D	18	900 W per rm	500

Note: * 10 W per person for sensible heat and 10 W per person for latent heat.

Table A3. Space type categories: default assumptions

						Service Water Heating (W-person)
Office						
General	8	8	A	25	25	As design
Hi-tech	8	8	A	25	50-70	As design
Lift lobby	10	1 l/s/m^2	A	22	---	As design
Reception/Waiting/ Recreation room	8	8	A	22	---	As design
Data centre (server, mainframe computer)	10-15	8	A	25	500-900	As design
Bank business area	10	8	A	As design (max. 25)	30	As design
Bank customer area	1.5	0.25 l/s/m^2	A	As design (max.15)	---	As design
Restaurant						
Chinese restaurant	1	10	B	As design (max. 90)	20 W/psn *	As design
Western restaurant	1.5	10	B	As design (max. 40)	20 W/psn *	As design
Coffee shop/ Bar/ Lounge (smoking allowed)	1.5	15	B	As design (max. 40)	10	As design
Canteen/food plaza	1	10	B	As design (max. 40)	20 W/psn *	As design
Kitchen	As design	As design	As design	22	As design	As design
Retail						
Retail shop	2.5	8	C	As design (max. 60)	30	As design
Shopping arcade	2.5	8	C	As design (max. 45)	10	As design
Supermarket	12.5	8	C	As design (max. 30)	5-10	As design

						Service Water Heating (W-person)
Educational activities						
Classroom/Lecture theatre/Laboratory	2 (or no. of seat)	8	A	25	10	As design
Library	5	8	A	25	10	As design
Mass assembly area						
Auditorium	5	8	C	35	5-10	As design
Exhibition hall /gallery	5	8	C	25	5-10	As design
Mass assembly area/assembly hall	1	8	E	25	5-10	As design
Theatre – Performing arts	2 (or no. of seat)	8	E	As design (max. 19)	---	As design
	2 (or no. of seat)	8	E	As design (max. 14)	---	As design
Indoor sports grounds						
Spectator seating area	1.5	8	F	20	---	As design
Indoor sports ground for amateur players	3	13	F	22	---	As design
Indoor sports ground for tournament	As design	13	F	28	---	As design
Squash courts for amateur players	2 persons	13	F	25	---	As design
Squash courts for tournament	2 persons	13	F	40	---	As design
Indoor swimming pool for amateur players	3	13	F	16	---	As design
Indoor swimming pool for tournament	As design	13	F	19	---	As design
Ice rink for amateur players	3	13	F	19	---	As design
Ice rink for tournament	As design	13	F	34	---	As design
Hotel						
Banquet room	1	10	B	40	20 W/psn(*)	90
Back-of-house area	4	8	G	As design (max.15)	20 W/psn(*)	60
Main entrance/large lobby	10	1 l/s/m^2	G	As design (max.18)	---	30
Health club	8-10	13	F	As design (max.22)	---	90
Guest rooms	As design (or 2 per rm)	30 l/s/room	D	25	900 per room	500

Note: * 10 W per person for sensible heat and 10 W per person for latent heat.

Use values in Lighting Code Table (LG4) for spaces not listed in this table.

Table A4. Operating schedule 'A': offices

																								24
Occupants																								
Mon – Fri	0	0	0	0	0	0	0.1	0.7	0.9	0.9	0.9	0.5	0.5	0.9	0.9	0.9	0.7	0.3	0.1	0.1	0.1	0.1	0	0
Sat	0	0	0	0	0	0	0.1	0.4	0.7	0.7	0.7	0.7	0.7	0	0	0	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment																								
Mon – Fri	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.3	0.2	0.2	0.2	0.2
Sat	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sun	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Lighting																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.3	0.1	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.6	0.5	0.5	0.3	0.3	0.1	0.1	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fans																								
Mon – Fri	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Cooling	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Heating	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Hot Water																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.3	0.2	0.2	0.2	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table A5-1 Operating schedule 'B-1': western restaurants

																								24
Occupants																								
Mon – Fri	0.1	0	0	0	0	0	0	0	0.1	0.2	0.5	0.9	0.9	0.8	0.2	0.2	0.3	0.6	0.9	0.9	0.9	0.6	0.4	0.3
Sat	0.3	0	0	0	0	0	0	0	0.1	0.2	0.5	0.9	0.9	0.8	0.2	0.2	0.3	0.6	0.9	0.9	0.9	0.6	0.6	0.5
Sun	0.3	0	0	0	0	0	0	0	0.3	0.4	0.7	0.9	0.9	0.9	0.7	0.5	0.4	0.6	0.9	0.9	0.9	0.5	0.4	0.3
Equipment																								
Mon – Fri	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5
Lighting																								
Mon – Fri	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5
Fans																								
Mon – Fri	On	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling	(*) = temperature as design																							
Mon – Fri	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Heating	(*) = temperature as design																							
Mon – Fri	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Hot Water																								
Mon – Fri	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.5	0.5	0.6	0.6	0.5	0.3	0.3	0.5	0.5	0.8	0.8	0.9	0.9	0.6
Sat	0.6	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.5	0.5	0.6	0.6	0.5	0.3	0.3	0.5	0.5	0.8	0.8	0.9	0.9	0.7
Sun	0.6	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.5	0.5	0.6	0.6	0.5	0.3	0.3	0.5	0.5	0.8	0.8	0.9	0.9	0.5

Table A5-2 Operating schedule 'B-2': Chinese restaurants

																								24
Occupants																								
Mon – Fri	0	0	0	0	0	0	0.5	0.7	0.7	0.5	0.5	0.9	0.9	0.8	0.2	0.2	0.3	0.6	0.9	0.9	0.8	0.3	0.1	0
Sat	0	0	0	0	0	0	0.4	0.6	0.7	0.6	0.6	0.8	0.9	0.8	0.2	0.2	0.3	0.6	0.9	0.9	0.8	0.3	0.1	0
Sun	0	0	0	0	0	0	0.4	0.6	0.7	0.8	0.8	0.9	0.9	0.9	0.7	0.5	0.4	0.6	0.9	0.9	0.8	0.3	0.1	0
Equipment																								
Mon – Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.7	0.9	0.9	0.9	0.8	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.7	0.3	0.1
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.7	0.9	0.9	0.9	0.8	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.7	0.3	0.1
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.7	0.7	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.7	0.3	0.1
Lighting																								
Mon – Fri	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.1
Sat	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.1
Sun	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.1
Fans																								
Mon – Fri	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Heating	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Hot Water																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.7	0.3	0.3	0.3	0.5	0.6	0.8	0.8	0.5	0.3	0.1
Sat	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.7	0.3	0.3	0.3	0.5	0.6	0.8	0.8	0.5	0.3	0.1
Sun	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.6	0.8	0.8	0.8	0.5	0.3	0.1

Table A6. Operating schedule 'C': retails

																								24
Occupants																								
Mon – Fri	0	0	0	0	0	0	0	0.1	0.2	0.5	0.5	0.7	0.7	0.7	0.7	0.8	0.7	0.6	0.5	0.4	0.3	0	0	0
Sat	0	0	0	0	0	0	0	0.1	0.2	0.5	0.6	0.7	0.7	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.6	0	0	0
Sun	0	0	0	0	0	0	0	0	0.1	0.3	0.6	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0	0	0
Equipment																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Lighting																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.05	0.05	0.05
Fans																								
Mon – Fri	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off
Cooling	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Heating	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off	Off
Hot Water																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.3	0.4	0.8	0.8	0.8	0.8	0.6	0.4	0.3	0.2	0.2	0.2	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.3	0.5	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.5	0.4	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.3	0.4	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.5	0.4	0.05	0.05	0.05

Table A7. Operating schedule 'D': hotels

																								24
Occupants																								
Mon – Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.7	0.7	0.8	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.6	0.6	0.6	0.7	0.7	0.7
Sun	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.6	0.8	0.8	0.8
Equipment																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.5	0.3
Sat	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.2	0.2	0.2
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.2	0.2	0.2
Lighting																								
Mon – Fri	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.8	0.9	0.8	0.6	0.3
Sat	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.3
Sun	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.7	0.8	0.6	0.5	0.3
Fans																								
Mon – Fri	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling	(*) = temperature as design																							
Mon – Fri	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Heating	(*) = temperature as design																							
Mon – Fri	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Hot Water																								
Mon – Fri	0.3	0.2	0.1	0.1	0.2	0.4	0.6	0.9	0.7	0.5	0.5	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.5	0.7	0.7	0.7	0.7	0.5
Sat	0.3	0.2	0.1	0.1	0.2	0.4	0.5	0.8	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.5	0.7	0.7	0.7	0.7	0.5
Sun	0.3	0.2	0.1	0.1	0.2	0.4	0.4	0.6	0.9	0.7	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.6	0.6	0.6	0.6	0.5

Table A8. Operating schedule 'E': theatres

																								24
Occupants																								
Mon – Fri	0	0	0	0	0	0	0	0	0	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.8	0.8	0.8	0.5	0	0
Sat	0	0	0	0	0	0	0	0	0	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0	0
Sun	0	0	0	0	0	0	0	0	0	0.5	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0	0
Equipment																								
Mon – Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Lighting																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Fans																								
Mon – Fri	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Cooling	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Heating	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Hot Water																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.8	0.8	0.8	0.5	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.05	0.05

Table A9. Operating schedule 'F': sports

																								24
Occupants																								
Mon – Fri	0	0	0	0	0	0	0.3	0.4	0.5	0.5	0.5	0.3	0.3	0.3	0.4	0.5	0.5	0.6	0.8	0.8	0.8	0.5	0	0
Sat	0	0	0	0	0	0	0.3	0.4	0.5	0.7	0.8	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.5	0	0
Sun	0	0	0	0	0	0	0.3	0.4	0.5	0.7	0.8	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.5	0	0
Equipment																								
Mon – Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.5	0.9	0.9	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.7	0.7	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.7	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.1	0.1
Lighting																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.05	0.05
Fans																								
Mon – Fri	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Sat	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Sun	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Cooling	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sat	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sun	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Heating	(*) = temperature as design																							
Mon – Fri	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sat	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Sun	Off	Off	Off	Off	Off	Off	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Off	Off
Hot Water																								
Mon – Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.3	0.4	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.5	0.6	0.8	0.8	0.8	0.5	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.6	0.7	0.7	0.5	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.5	0.6	0.8	0.8	0.5	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.05	0.05

Table A10. Operating schedule 'G': common activities areas

																								24
Occupants																								
Mon – Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Equipment																								
Mon – Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Lighting																								
Mon – Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Fans																								
Mon – Fri	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling	(*) = temperature as design																							
Mon – Fri	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Heating	(*) = temperature as design																							
Mon – Fri	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sat	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Sun	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Hot Water																								
Mon – Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

4. Building Envelope

4.1 *Infiltration*. Infiltration assumptions shall use the prescribed assumptions for calculating the total energy budget and default assumptions for the design energy consumption. Infiltration shall impact only perimeter zones. When the HVAC system is ON, no infiltration shall be assumed to occur. When the HVAC system is OFF, the infiltration rate for exterior walls of the building with entrance doors/revolving doors or with operable windows shall be assumed to be: (a) for glazed entrance doors and for revolving doors, 5 l/s per m^2 of door area, and (b) for operable windows, 2 l/s per m^2 of the respective window area.

4.2 *Envelope and Ground Absorptivities*. Absorptivity assumptions shall be prescribed assumptions for the reference building and default assumptions for the designed building. The solar absorptivity of opaque elements of the building envelope shall be assumed to be 70 percent. The solar absorptivity of ground surfaces shall be assumed to be 80 percent (20 percent reflectivity).

4.3 *Window Management*. If the plans and specifications show interior shading devices which perform better than a medium-colored Venetian blind, then those shading devices may be modelled in the designed building, and the reference building shall be modelled with medium-colored Venetian blinds. Otherwise, interior shading shall be modelled identically in the proposed and reference buildings, either with medium-colored Venetian blinds or without interior shades.

4.4 *Shading*. For reference buildings and the designed building, shading by permanent structures, terrain, and vegetation may be taken into account for computing energy consumption, whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the proposed design.

4.5 *Window Areas*. The fraction of total window area in each orientation should be equal for both the reference and designed building. For example, if the designed building has 40% of window area facing north, then the reference building shall also have 40% of window area facing north.

4.6 *Thermal Mass*. If no information is available for determining the thermal mass of the building envelope, medium weight construction shall be assumed in the modelling.

5. HVAC Systems

5.1 *Thermal Blocks and HVAC Zones*. Thermal blocks for the reference building and designed building shall be identical. Where HVAC zones are defined on HVAC design documents, each HVAC zone shall be modelled as a separate thermal block. Different HVAC zones may be combined to create a single thermal block or identical thermal blocks to which multipliers are applied provided all of the following conditions are met:

(a) The space use classification is the same throughout the thermal block.

(b) All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees of each other.

(c) All of the zones are served by the same HVAC system or by the same kind of HVAC system.

5.2 *HVAC Zones Not Designed*. Where the HVAC zones and systems have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines:

(a) Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 4 m from an exterior wall. Perimeter spaces shall be those located closer than 4 m from an exterior wall.

(b) Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls; a separate zone shall be provided for each orientation, except orientations that differ by no more than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 4 m or less from a glazed perimeter wall, except that floor area within 4 m of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.

(c) Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.

(d) Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

5.3 *Supply Air Flow Rates*. The design air flow rate for each thermal block of the designed building shall be automatically calculated by the simulation program based on the design cooling supply air temperature and heating supply air temperature.

5.4 *Performance Parameters*. The HVAC system's performance parameters for the reference building shall be determined from the following rules:

(a) Components and parameters not specifically addressed in this Code shall be identical to those in the designed building. Where there are specific requirements in the Air Conditioning Code, the component efficiency in the reference building shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

(b) All HVAC equipment in the reference building shall be modelled at the minimum efficiency levels, both part load and full load, in accordance with the requirements in the Air Conditioning Code.

(c) Where equipment efficiency ratings include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modelled separately.

(d) Minimum outdoor air ventilation rates shall be the same for both the reference building and designed building.

(e) System design supply air flow rates for the reference building shall be based on a supply-air-to-room-air temperature difference of 11°C. If return or relief fans are specified in the designed building, the reference building shall also be modelled with the same fan type sized for the reference system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

(f) Fan system efficiency (kW per L/s of supply air including the effect of belt losses but excluding motor and motor drive losses) shall be the same as the designed building or up to the limit prescribed in the Air Conditioning Energy Code, whichever is smaller.

(g) The equipment capacities for the reference building design shall be sized proportionally to the capacities in the designed building based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the designed building and reference building. Unmet load hours for the designed building shall not differ from unmet load hours for the reference building design by more than 50 hours.

6. Service Water Heating

6.1 *Loads*. The service water heating loads for reference buildings are defined in Tables A2 and A3. The same service water heating load assumptions shall be made in calculating design energy consumption as were used in calculating the total energy budget.

6.2 *Fuels*. The fuel assumed for the service water heating equipment of the reference building shall be the same as that for the designed building.

7. Controls

7.1 *Space Temperature Controls*. Space temperature controls for the reference building shall be the same as the designed building. The system shall be OFF during off-hours according to the appropriate schedule in Tables A4 to A10.

7.2 *Throttling Range*. The throttling range of room thermostat shall be set to no greater than 1°C.

7.3 *Outside Air Ventilation*. When providing for outdoor air ventilation when calculating the total energy budget, controls shall be assumed to close the outside air intake to reduce the flow of outside air to zero during "setback" and "unoccupied" periods. Ventilation using inside air may still be required to maintain scheduled setback temperature.

8. Speculative Buildings

8.1 *Lighting*. The interior lighting power density for calculating the total energy budget shall be determined from Tables A2 and A3. The design energy consumption may be based on an assumed adjusted lighting power for future lighting improvements. The assumption about future lighting power used to calculate the design energy consumption shall be documented so that the future installed lighting systems may be in compliance with this assumption.

8.2 *HVAC Systems and Equipment*. If the HVAC system is not completely specified in the plans, the design energy consumption shall be based on reasonable assumptions about the construction of future HVAC systems and equipment. These assumptions shall be documented so that future HVAC systems and equipment may be in compliance with this assumption.

Appendix IV – Standard Forms for Submission

Form PB-1	Compliance Summary
Form PB-2	Basic Requirements Checklist
Form PB-3	Numerical Method and Software
Form PB-4	Key Building Data Summary
Form PB-5	List of Energy-related Features for Trade-off

The forms shall be expanded to include all equipment under application. Additional sheets shall be used as appropriate.

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-1

A. Applicant Information

Name of organisation:		
Telephone no.:		
Fax no.:		
E-mail:		
Registered Professional Engineer (RPE) responsible for the compliance:	Name: RPE no.: Discipline:	Telephone no.: Fax no.: E-mail:
Signature:		
Date:		

B. Project Information

Project/Building name:	
Project/Building address:	
Primary building type:	
Other building usage(s):	
No. of storeys:	
Building height (m):	
Gross floor area (m^2):	
Floor area (m^2):	
Air-conditioned floor area (m^2):	
Construction starting date:	
Expected completion date:	

C. Summary of Building Energy Performance

		Reference Building
Design energy consumption (kWh)		-----
Total energy budget (kWh)	-----	
Energy use intensity (kWh/m^2/year) (based on gross floor area)		

D. Renewable or Recovered Energy

Have you considered "renewable energy" or "recovered energy" and excluded it in the design energy consumption? Yes / No * (* delete where applicable)

If yes, please provide detailed information and calculation for the "renewable energy" or "recovered energy". Use additional sheets if necessary.

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-2

1. Building Envelope

Building (Energy Efficiency) Regulation Cap.123 Sub. Leg. M	
Shading coefficient of window glasses shall be not less than 0.25.	

2. Lighting

• Minimum allowable luminous efficacy [Lighting Code 4.1] • Maximum allowable lamp control gear loss [Lighting Code 4.2] • Interior lighting control [Lighting Code 4.4]	

3. HVAC

Air Side System • System load design [Air Conditioning Code 4] • Separate distribution system [Air Conditioning Code 5.1.1] • Air leakage limit on ductwork [Air Conditioning Code 5.1.2]	
Water Side System • Pumping system variable flow [Air Conditioning Code 6.1] • Friction loss [Air Conditioning Code 6.2]	
Control • Temperature control [Air Conditioning Code 7.1] • Humidity control [Air Conditioning Code 7.2] • Zone control [Air Conditioning Code 7.3] • Off hours control [Air Conditioning Code 7.4]	
Insulation • Piping insulation [Air Conditioning Code 8] • Ductwork and AHU casing insulation [Air Conditioning Code 8]	

4. Electrical

Power Distribution in Buildings • High voltage distribution [Electrical Code 4.1] • Minimum transformer efficiency [Electrical Code 4.2] • Locations of distribution transformers and main LV switchboards [Electrical Code 4.3] • Main circuits [Electrical Code 4.4] • Feeder circuits [Electrical Code 4.5] • Sub-main circuits [Electrical Code 4.6] • Final circuits [Electrical Code 4.7]	
Efficient Utilisation of Power • Motors and drives [Electrical Code 5.4] • Power factor improvement [Electrical Code 5.5]	
Power Quality • Maximum total harmonic distortion [Electrical Code 6.1] • Balancing of single-phase loads [Electrical Code 6.2]	
Metering and Monitoring Facilities • Main circuits [Electrical Code 7.1] • Sub-main and feeder circuits [Electrical Code 7.2]	

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-2 (cont'd)

5. Lift & Escalator

Lifts • Maximum allowable electrical power [Lift/Escalator Code 4.1] • Energy management of lift cars [Lift/Escalator Code 4.2] • Total harmonic distortion of motor drive systems [Lift/Escalator Code 4.3] • Total power factor of motor drive systems [Lift/Escalator Code 4.4]	
Escalators & Passenger Conveyors • Energy management of escalators & passenger conveyors [Lift/Escalator Code 5.1] • Maximum allowable electrical power of escalators & passenger conveyors [Lift/Escalator Code 5.2] • Total harmonic distortion of motor drive systems [Lift/Escalator Code 5.3] • Total power factor of motor drive systems [Lift/Escalator Code 5.4]	

[Support Documentation]

	No. of pages

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-3

1. General Information

Name of software/method:	
Software version number:	
Software release number (if any):	
Name of software license owner:	

2. Software Developer/Supplier

Organisation that developed the software	
Organisation that supplied the software:	

3. Climatic Data

Climatic data used for the analysis:	
Format and nature of the climatic data:	

4. Systems or Equipment Not Yet Determined But Assumed

	Description

5. Other Modelling Assumptions

	Description

6. Limitations of the Software/Method

	Description

[Support Documentation]

	No. of pages
Input building description file (printed and electronic format)	
Output reports file (printed and electronic format)	

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-4

		Reference Building
1. General Information		
Total gross floor area (m^2)		
Average occupant density (m^2/person)		
Minimum outdoor air (l/s per person)		
2. Building Envelope		
Gross wall area (m^2)		
Window-to-wall ratio		
Shading coefficient of windows		
Gross roof area (m^2)		
Skylight-to-roof ratio		
Shading coefficient of skylights		
OTTV of exterior walls (W/m^2)		
OTTV of roof (W/m^2)		
External shading device provided?		
3. Lighting		
Average lighting power density (W/m^2)		
Daylighting design provided? How?		
4. HVAC		
Number of Chillers		
Total cooling capacity (kW)		
Total heating capacity (kW)		
Type of air side system		
Total design supply air flow rate (m^3/s)		
Type of chiller plant		
Chiller coefficient of performance (kW/kW)		
5. Electrical		
Total installed equipment capacity (kW)		
Average equipment power density (W/m^2)		
6. Service Hot Water		
Service hot water provided? Fuel?		
Total heating capacity (kW)		

Performance-Based Building Energy Code

Job Ref. No._____

	Form PB-5

	Description

[Support Documentation]

	No. of pages